Physical and Chemical Properties of NEOs

John S. Lewis
LPL, University of Arizona
Tucson, Arizona

The physical and chemical consequences of comet and asteroid impacts are strongly dependent on the physical state, chemical composition, and entry conditions of the impacting body. Knowledge of the physical properties of asteroidal material is nearly nonexistent, being limited to radar data showing the duplicity of a handful of NEAs, imaging of two Belt asteroids by *Galileo* on its way to Jupiter, and thermal data that generally requires the presence of regolith on large Belt asteroids. The densities, porosities, and crushing strengths of a number of individual meteorites from several different compositional classes have been measured in the laboratory, and crude extrapolations of the crushing strength from measurements made on specimens the scale of a kilogram can be done using a Weibull strength law. Cometary material probably exhibits at least three different strengths, associated with the surface lag deposit of fluffy dust (weak cometary meteors), gravitational bonding of large structural blocks (near-zero physical "welding" strength), and crushing of these massive permafrost blocks (strengths comparable to sedimentary rocks). Our lack of first-hand evidence regarding the structures and strengths of small asteroids and comets is a serious limitation on our ability to model entry or interdiction behavior.

The chemical composition of the impacting body is important in several respects. On Earth, the sulfur content of the impactor is highest for those bodies that fragment most readily at high altitudes, the carbonaceous chondrites. Massive injection of sulfur occurs at high altitudes, where formation of sulfur dioxide and oxidation to sulfuric acid are critically important. Sulfate aerosols generated in the stratosphere may have devastating short-term climatic effects which would be devastating to agriculture for a few weeks, but which would not be capable of producing a global extinction signature that would be discernible in the paleontological record. Massive sulfur injection represents a selective threat to civilization, not to species diversity. Co-injection of water along with sulfur help in the rapid formation of massive sulfuric acid aerosols. Injection of platinum-group metals is already recognized as an important (albeit highly variable and over-rated) marker of large impacts. On other planets, injection of water and other volatiles may be the most important chemical effect, pointing to possible influence of cometary impacts on the early biosphere of Earth.

The interaction of orbital parameters, entry velocity, entry angel, size-dependent crushing strength, and chemical composition governs the deposition profiles of energy, momentum, mass, and sulfur in the terrestrial atmosphere. Monte Carlo simulations are uniquely suited to modeling these multidimensional interactions.